

Implementation and Evaluation of GIS using IPT

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Abstract

We will show the design of the new system utilizing GIS (Geographic Information Systems). 3D-geographic information of Nagasaki-shi was constructed from tracing the aerial photograph and adding the height information of measured buildings. In large multi-plane stereo presentation equipment called IPT (Immersive Projection Technology), this 3D-map was presented in actual scale. As the result, the observer could obtain three-dimensional information of various lands as direct experience, in spite of there being the self in the IPT inside. Furthermore, we set a treadmill, an ambulation device, in the inside of the IPT. When it synchronized to the walking of the observer and scene change, it seemed to obtain the more accurate spatial information. Finally, we conducted an experiment for evaluation of this system. If the virtual town in the system is similar to the actual one, virtual experience come useful for real life.

Key words: IPT, GIS, 3D-map, VR, VRML, Evaluation

1. Introduction

Recently, the movement that intends to utilize cooperated GIS database is activated in the Japanese government. In the local government of each prefecture, peculiar administration support model using the various GIS database is proposed. In the Seihi town in Nagasaki Prefecture, the welfare support system by GIS technique is made. It is a purpose to attempt database preparation and reduction in the cost that depends on the maintenance for the each every post of the administration. It is not fixed only in improving the efficiency improvement of the administration business according to the GIS database. Constructed database spreads to various utilization fields by adding the GIS technology. This study is that it adds 3D image reproduction technology and virtual reality technology to the GIS database and shows the possibility of utilizing as townscape simulation information.

2. Present state of the townscape simulation

Until now, it is the mainstream that the simulation makes landscape model of the object area in respect of the

townscape. For the landscape simulation of the good accuracy, the building feature is stuck in the model. The partial correction is difficult for this model, and it is easy to deteriorate, and permanent preservation is not possible. In such work of the labor, this model needs very much large cost and work period. It is also simple to correct the model, if this model is realized on the computer, and permanent preservation is also possible. And, the simulation is possible always, when they are necessary. For the Tateyama district in Nagasaki, the computer simulation model (the GIS database) was made. And, this model was carried out in virtual reality expression equipment (IPT).

3. The research area

Research region of this study chose representative hillside area (the Tateyama district) in the Nagasaki City. The Tateyama district is a optimum region of the object of the modeling. Hillside area of the Nagasaki City was formed in the high growth period after 1960's. There was no correspondence performance on hillside area of Nagasaki in the movement of the motorization in 1980's. Therefore, hillside area became a region where decrease of the young generation and hollowing of the population and aging advanced. The simulation for the regional activation is a necessary region on hillside area from the viewpoint of community planning. In this study, for the reason of the superscription, Tateyama district (zone from the Tateyama 1 chome to 5) in the Nagasaki City was digitized as a map of the 1/2500 accuracy. 3D image of the Tateyama district was made using this digital map. And, the feature of the building was stuck in the 3D image. Finally, the townscape simulation was carried out on IPT for the Tateyama district.

4. The GIS data improvement

4.1 The GIS basis data

There are so many GIS data in Japan. The digital map in Japan issues all 21 types (National Land Agency: 8 type Geographical Survey Inst.: 13 type). In this inside, numerical value map of 2500 (spatial databases) has the sufficient utilization accuracy as a GIS data. However, there is no this data in present, August 2000, Nagasaki City. Then, the digital numerical value map was made



Fig. 1 Tracing work of digital map

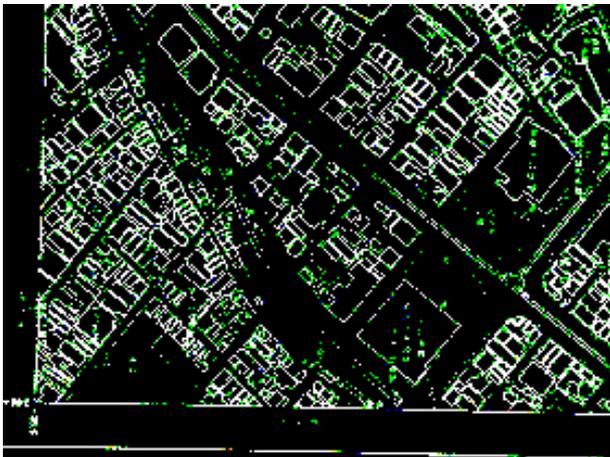


Fig. 2 Ended sheet of tracing work

from the city planning map (the Tateyama district map (No.62, No.72): 1/2500 accuracy) of 2 sheets.

4.2 From the city planning map of 2 sheets to the numerical value map

4.2.1 Graphical data

From the city-planning map of 2 sheets, digital elevation model (DEM) of topographic data (point information measured with the contour line) was made. Spatial data made building information, administration field zone information, road and stair information, railway and train route information, coastline information as layer information. Figure.1 is tracing work photograph. And, Figure.2 is the ended sheet of tracing work.

4.2.2 DEM Data

DEM Data of this study is the triangulation irregular network (TIN) model. TIN makes the triangle group arise from landform point placing in the random state, and it is a kind of making DEM. The reason for choosing TIN in this study as a DEM model is because the model of which the generation of DEM is possible at the good accuracy from contour line and measure point

(No.62 are 440 points, 320 points, sum total of 760 points No.72). However, the tracing work was carried out in this study at the 10m unit. Vector data of the contour line is converted as line information, and altitude data of the contour line is input into each line information as attribution information. Measurement point placed in the random state becomes the very effective data in order to make TIN. However, the detailed DEM preparation is difficult in the mountainous area, because the measurement point is little. And, there is a weak point in which the expression near the summit is scarce in the case of TIN according to contour line. In this study, TIN (Figure.3) got from contour line of mountainous area and TIN (Figure.4) got from measurement point of the random state are superimposed, and TIN (Figure.5) of the detailed Tateyama district make. Figure.6 extracted administration field zone from the Tateyama 1-chome to 5-chome.

4.2.3 Spatial data

Spatial data input administration field zone and building

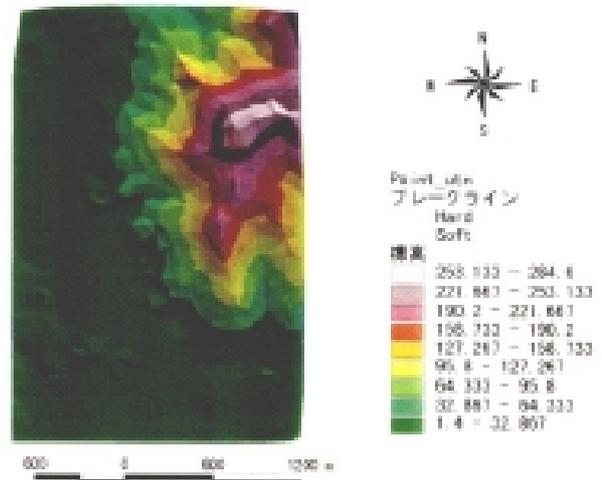


Fig. 3 TIN made by measure points

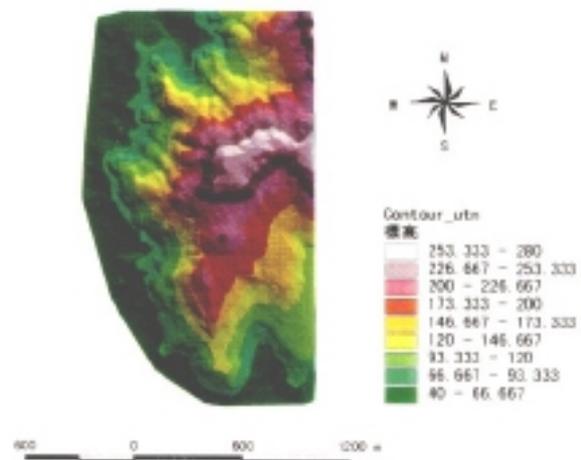


Fig. 4 TIN made by 10m contour

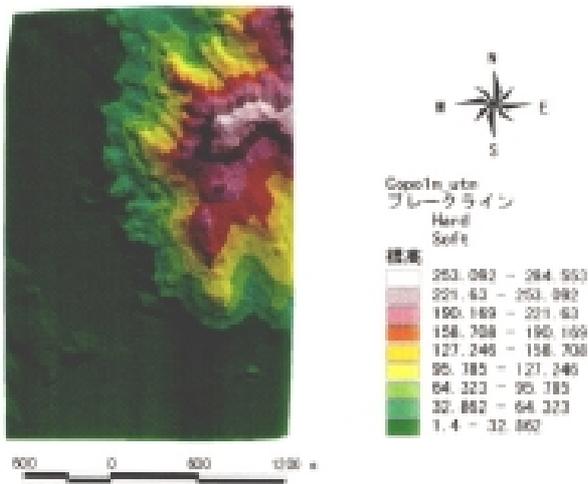


Fig. 5 TIN made by points and contour

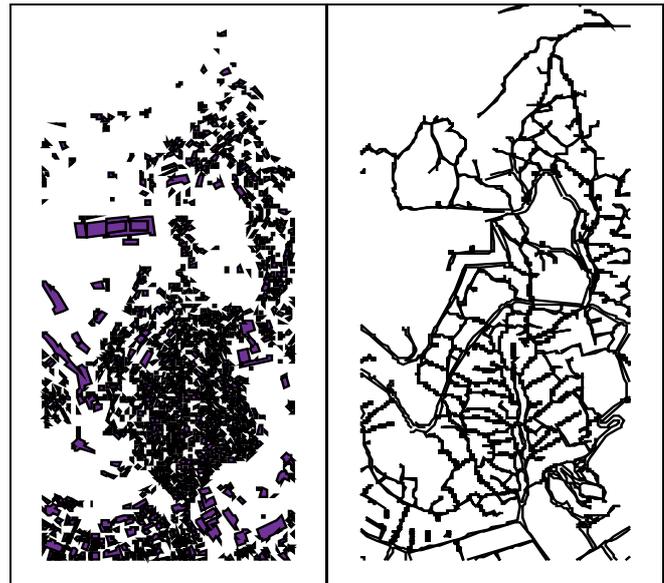


Fig. 7 Spatial data (building & road).

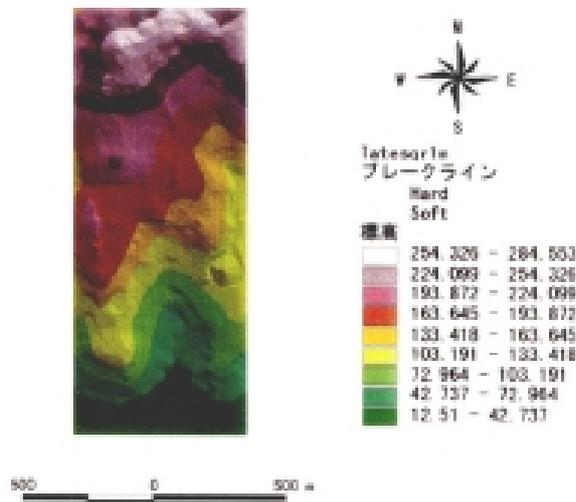


Fig. 6 Finished TIN in this study



Fig. 8 VRML image of Tateyama region

and coastline information as a polygon data. And, the following are input as a line data: Road and stair and railway and train route of spatial data. Figure.7 is spatial data that show building and road. The attribution data of the building input classification (wooden construction and non-wooden construction and concrete, etc.), nameplate and building application (it is classified into 22 types such as housing, store, public facility) with the rank. And, vacant land and plowed field, parks and planned road and plan parks, etc. are added information.

4.2.4 3D image (VRML)

The 3D-preparation image was made to be VRML format that could grasp the whole town. Figure.8 is 3D image that converted as a VRML format. By adding the feature, the image on IPT used it.

5. Simulation of Urban View in IPT

Observers can experience virtual world by Immersive Projection Technology (IPT), which is constituted of

multi wide-screens and stereo system utilizing liquid-crystal-shutter or polarized plastic framed glasses. In this study to simulate urban views, we used IPT having front, both sides and floor screens. Graphics work station (Onyx2) stored VRML files and projected them using Performer library. Figure.9 shows the simulation of whole town. As original maps have cross-sections of buildings with height information only, all buildings seem like simple boxes. To make more reality, we will have to add roofs of Japanese houses and so on. Figure.10 shows different scale views. Observers can see the town from aerial view and enter the same scale town as real world. Building's windows and entrances were obtained by texture mapping using digital photograph taken at the places. The advantages of simulation GIS in IPT are that observers can see views from various angles and change scale size as if they are in the town. Furthermore, if we set a treadmill in the inside of IPT and the rotation speed of the belt synchronizes images, observers can experience walking sensation in the town

(see Figure.11). In addition, our treadmill can change the slope of the belt, and then some sensation of going up an ascent can be obtained too.

6. Evaluation of GIS in IPT

Next, we conducted an experiment for evaluation of GIS in IPT. If the virtual town in the system is similar to the actual one, virtual experience will come useful for real life. Here, we observed the walking performance to go to a goal point in real world with learning the route in IPT.

6.1 Method

Figure.12 shows the route, in Tateyama 2-Choume,



Fig. 9 Whole town in IPT

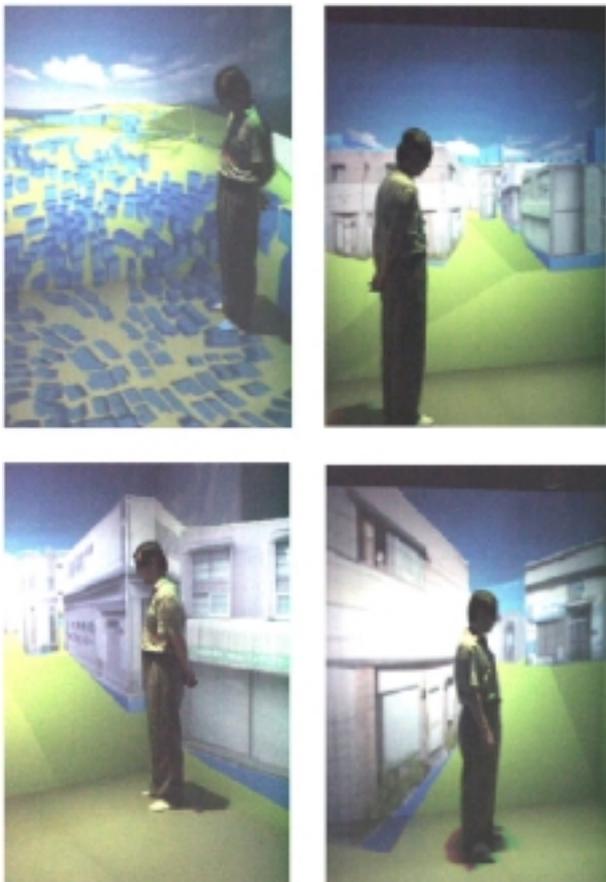


Fig. 10 Various scale views from various angle



Fig. 11 Walking with treadmill in IPT

which subjects walked from the start point to the goal point. Ten subjects who haven't been to the route were divided into following two groups of five subjects (two females and three males).

IPT group (IG): Subjects learned the route in IPT before walking in real world. They stood in the center of IPT, and the real-scale image was flowed at 3 km/hour, as if walking the route. The building's textures were obtained at the place. Learning the route was repeatedly until they could memorize the route. The interval of learning repetitions was 7 min. In order to check extent of subject's memory, a red ball, which had 1 m radius, was presented at the parting of the route for about 4 seconds just before bending. Subjects had to report which road they should take during the ball being with the except of the first leaning. At the first learning, they were instructed to ignore the ball. When all bending were correct, learning term terminated. After that, subjects must report the sequence of which bending each parting from the first corner (e.g. right, right, left, ... or left, right, left... etc.). There was possibility of judging the route by merely sequence of right and left, despite we asked them to memorize the route utilizing virtual scenes before learning. This result was used to check subject's strategy. About 1 hour later, they arrived at the start point in Tateyama 2-Choume by car, and were asked to walk the route to go to the goal point. If subjects took a wrong course, the experimenter taught them real one. We recorded subject's behavior on video.

IPT with treadmill group (ITG): Almost all conditions were same as IG's ones, except for using the treadmill, which was synchronized with the image, in IPT. One might suppose that walking is useful for memorizing distance from the corner to the next one. If walking in learning the route is important factor, ITG will perform better than IG.

6.2 Results

6.2.1 Learning in IPT

Since the learning implies training for subjects to memorize the route, the number of learning repetition doesn't include last repetition at which they could decide all bending correctly. Figure 13 shows the average of

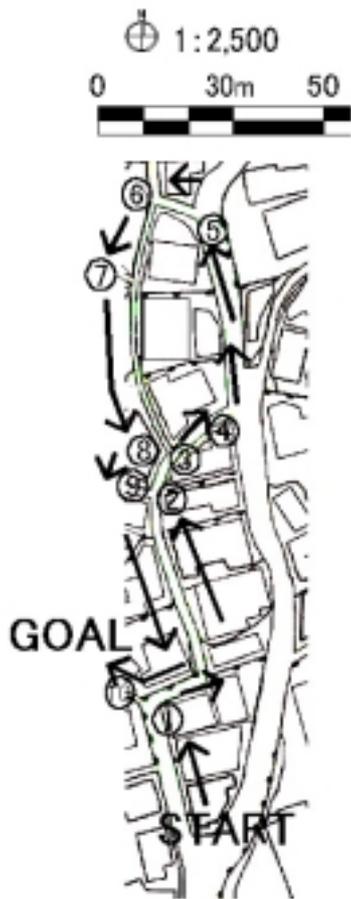


Fig.12 The route in this experiment

learning repetitions across all subjects for each group; error bars represent standard deviation. There is significant difference between IG (1.6 repetitions) and ITG (2.6 repetitions) ($t(8) = 2.89, p < .05$). The right column of Table.1 gives the corners that each subject decided incorrectly in the learning. Incorrect decisions were concentrated at corner 9 and 10.

6.2.2 Walking in real world

Figure.14 shows a walking appearance of a subject. Figure.15 shows the average of incorrectly decided corners across all subjects for each group. There is no difference between IG and ITG ($t(8) = 0, p > .1$) and the averages are 1.2 times in both group. If subjects decided the route at random, ie ineffective learning in IPT, the number would be five (chance level). The left column of Table.1 gives the corners that subjects decided incorrectly in the route. Incorrect decisions were concentrated at corner 5 and 10.

6.3 Discussion

We observed performance of walking in unknown place with learning in IPT to investigate how useful GIS in IPT is in real life. When subjects walked in real world after learning the route in IPT, even though the interval between learning in IPT and walking in real world was about 1 hour, incorrect decisions at partings were only

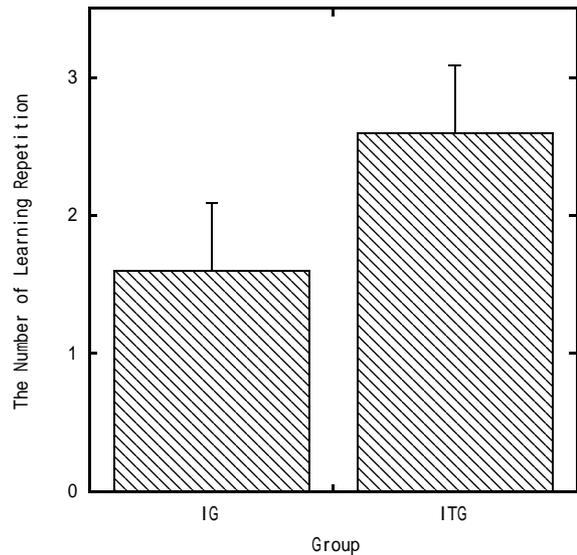


Fig. 13 The learning repetition for each group



Fig. 14 Walking appearance of a subject

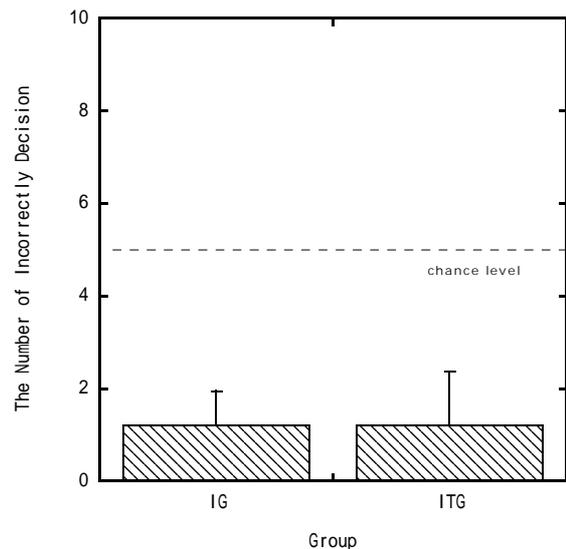


Fig. 15 The number of incorrectly decision for each group

1.2 times much less than the chance level. Thus, this virtual town made by GIS is similar to real one and useful for our life.

Table 1. Incorrect corner for each subject

Subjects	In Learning Term	In Real World
	<i>IG</i>	
NA	9(2)	7
AK	None	None
KY	3(2)	10
YO	3(2) , 9(2)	5 , 10
TS	None	5 , 10
	<i>ITG</i>	
SY	9(2)	None
TO	5(2) , 6(2) , 10(2)	5 , 6 , 10
EU	6(2) , 10(2) , 9(3)	10
SK	1(2) , 5(2) , 10(2) , 10(3)	None
HU	5(2) , 3(3)	5 , 10

()represents learning repetition

6.3.1 Learning with treadmill

Although there was no difference of incorrect decisions in real world between IG and ITG, ITG's subjects needed learning repetitions more than IG's ones to memorize the route perfectly. We expected that walking in IPT would be helpful to learn the route, whereas it made to memorize the route difficult. It is probably due to the complicated task which subjects viewed virtual scene and accompanied with the belt of the treadmill rather than simply viewing the scene. At least, using the treadmill interfered with leaning the route in present experiment. However, if the route was memorized in IPT, it is almost same for both groups that subjects could their the memory to real world.

6.3.2 Incorrect corners

Corner 9 and 10 were frequently mistaken in learning. Since the buildings around corner 9 are especially built-up as a small maze, it might take many times to memorize directions that subjects should take. Once the memory is stored, however, it isn't difficult to choose the route and no one mistook at the corner 9 in real world. At corner 10, the performance was bad in not only IPT but also real world. Mallot & Gillner⁽¹⁾ found that local landmarks are stronger cues than global configurations for route navigation. Around corner 10, there aren't outstanding buildings, therefore, it might be so difficult to memorize the route and apply their memory to real world. Also the street near corner 10 in IPT is broader than real world' one. Because we simply attached a wall surrounding a house to buildings as texture, the width between buildings didn't change from initial 2D map. It might be cause for subjects to mistake the route at corner 10 in real world. We would like to think details to pursuit more useful virtual system.

6.3.3 Strategy to memorize the route

How did subjects memorize the route in IPT? If they simply memorized a sequence of which bending each parting from the first corner (ie a word sequence of "right" and "left"), virtual experience in IPT isn't insignificant very much. Here we compare the sequences of correct report after learning term with the sequence of

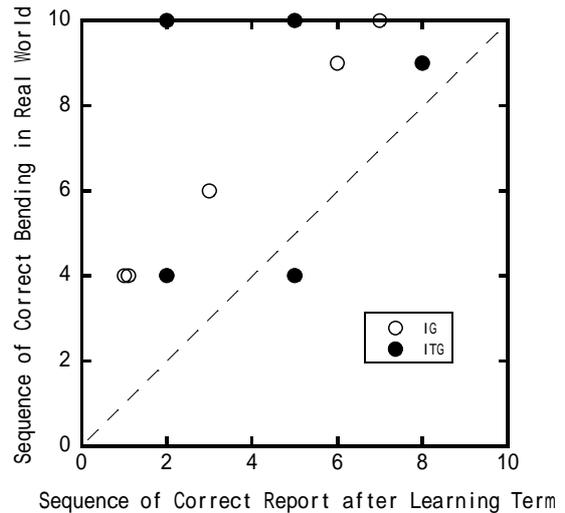


Fig. 16 Comparison sequence of correct report with sequence correct bending

correct bending from the start point in real world for each subject. The sequence of correct report means upper limit by means of the word sequence. If subjects utilized a word sequence only in real world, in Figure.16, each symbol should plotted under dashed line. However, almost all symbols plotted over the line mean that subjects utilized other cue to take directions at least. Thus, it is probably that real world enhanced memorized virtual scene and the scene navigated the route.

7. Conclusion

It is valuable for simulation of urban views, emergency prevention and navigation that GIS is implemented in IPT using computer technology. Our experiment supported that GIS in IPT is similar to real world and the virtual experience can come useful for our life. However, in present study, using printed maps to realize this system took a lot of time and labor. If 3D information from satellites will be obtained easily in the future, unknown places will appear in IPT very soon.

Reference

1. H. A. Mallot and S Gillner: "Route Navigating without Place Recognition: What is recognized in recognition-triggered responses?," *perception*, pp.43-55 (2000).